CLAIMS

We Claim:

1. A method for determining an unknown parameter of a semiconductor specimen using a semiconductor inspection system, the method comprising:

scanning a region of interest with an electron beam to cause X-rays to emanate from the region of interest;

detecting the X-rays from the region of interest using at least one X-ray detector wherein the detected X-rays are within a certain energy range spectrum and thereby form an experimental X-ray spectrum;

selecting a reference spectrum from an X-ray spectrum library based upon a set of inspection system parameters, a set of known semiconductor specimen parameters, and an initial estimated value for the unknown parameter;

generating a simulated spectrum using a spectrum simulation algorithm based upon the set of inspection system parameters, the set of known semiconductor specimen parameters, and the initial estimated value for the unknown parameter, wherein the simulated spectrum is generated when an appropriate reference spectrum is not part of the X-ray spectrum library;

comparing the experimental X-ray spectrum against either the reference spectrum or the simulated spectrum and determining the degree to which the experimental X-ray spectrum matches either the reference or simulated spectrum;

when the experimental X-ray spectrum does not match the reference or simulated spectrum to a satisfactory degree, repeating the selecting, generating, and comparing operations wherein a new estimated value for the unknown parameter is used in place of the initial estimated value for the unknown parameter; and

when the experimental X-ray spectrum does match the reference or simulated spectrum to a satisfactory degree, determining that the estimated value for the unknown parameter used to select the reference spectrum or to generate the simulated spectrum is approximately equal to the actual value of the unknown parameter.

2. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 1 further comprising:

acquiring an image of the region of interest on the semiconductor specimen; and

determining, from the image, the values of at least some of the parameters of the set of known semiconductor specimen parameters.

3. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 1 wherein at least some of the inspection system parameters includes electron beam parameters and X-ray detector parameters.

4. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 3 wherein the electron beam parameters includes at least the energy of the electron beam, the incident angle of the electron beam, the raster size and dimensions of the electron beam, and the electron beam current.

5. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 3 wherein the X-ray detector parameters includes at least the detector type, the energy resolution, the reference energy for energy resolution, the solid angle of the detector, and the polar and azimutal angles.

6. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 1 wherein the initial and new estimated value for the unknown parameter is an atomic number, and the unknown parameter describes the material composition of the region of interest.

7. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 1 wherein the simulated spectrum generated with the simulated spectrum algorithm is stored in the X-ray spectrum library.

8. A method as recited in claim 1 wherein the degree to which the experimental X-ray spectrum matches the reference or simulated spectrum is determined by using a simplex mathematical technique during the comparing operation.

9. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 1 further comprising:

selecting the initial estimate value of the unknown parameter based upon the experimental X-ray spectrum.

10. A method for determining an unknown parameter of a semiconductor specimen using a semiconductor inspection system, the method comprising:

scanning a region of interest with an electron beam to cause X-rays to emanate from the region of interest;

detecting the X-rays from the region of interest using at least one X-ray detector wherein the detected X-rays are within a certain energy range spectrum and thereby form an experimental X-ray spectrum;

generating a simulated spectrum using a spectrum simulation algorithm based upon the set of inspection system parameters, the set of known semiconductor specimen parameters, and the initial estimated value for the unknown parameter;

comparing the experimental X-ray spectrum against the simulated spectrum and determining the degree to which the experimental X-ray spectrum matches the simulated spectrum;

when the experimental X-ray spectrum does not match the simulated spectrum to a satisfactory degree, repeating the generating and comparing operations wherein a new estimated value for the unknown parameter is used in place of the initial estimated value for the unknown parameter; and

when the experimental X-ray spectrum does match the simulated spectrum to a satisfactory degree, determining that the estimated value for the unknown parameter used to generate the simulated spectrum is approximately equal to the actual value of the unknown parameter.

11. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 10 further comprising:

acquiring an image of the region of interest on the semiconductor specimen; and

determining, from the image, the values of at least some of the parameters of the set of known semiconductor specimen parameters.

12. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 10 wherein at least some of the inspection system parameters includes electron beam parameters and X-ray detector parameters.

13. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 10 wherein the initial and new estimated value for the unknown parameter is an atomic number, and the unknown parameter describes the material composition of the region of interest.

14. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 10 wherein the unknown parameter represents either a dimensional aspect of the specimen or a density measurement of the specimen.

15. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 10 wherein each of the simulated spectrums generated with the simulated spectrum algorithm is stored in an X-ray spectrum library.

16. A method as recited in claim 10 wherein the degree to which the experimental X-ray spectrum matches the reference or simulated spectrum is determined by using a simplex mathematical technique during the comparing operation.

17. A method for determining an unknown parameter of a semiconductor specimen as recited in claim 10 further comprising:

selecting the initial estimate value of the unknown parameter based upon the experimental X-ray spectrum.

18. A computer-readable medium comprising computer code for determining an unknown parameter of a semiconductor specimen using a semiconductor inspection system, the computer-readable medium comprising:

scanning a region of interest with an electron beam to cause X-rays to emanate from the region of interest;

detecting the X-rays from the region of interest using at least one X-ray detector wherein the detected X-rays are within a certain energy range spectrum and thereby form an experimental X-ray spectrum;

selecting a reference spectrum from an X-ray spectrum library based upon a set of inspection system parameters, a set of known semiconductor specimen parameters, and an initial estimated value for the unknown parameter;

generating a simulated spectrum using a spectrum simulation algorithm based upon the set of inspection system parameters, the set of known semiconductor specimen parameters, and the initial estimated value for the unknown parameter, wherein the simulated spectrum is generated when an appropriate reference spectrum is not part of the X-ray spectrum library;

comparing the experimental X-ray spectrum against either the reference spectrum or the simulated spectrum and determining the degree to which the experimental X-ray spectrum matches either the reference or simulated spectrum;

when the experimental X-ray spectrum does not match the reference or simulated spectrum to a satisfactory degree, repeating the selecting, generating, and comparing operations wherein a new estimated value for the unknown parameter is used in place of the initial estimated value for the unknown parameter; and

when the experimental X-ray spectrum does match the reference or simulated spectrum to a satisfactory degree, determining that the estimated value for the unknown parameter used to select the reference spectrum or to generate the simulated spectrum is approximately equal to the actual value of the unknown parameter.

19. A computer-readable medium as recited in claim 18 wherein the simulated spectrum generated with the simulated spectrum algorithm is stored in the X-ray spectrum library.